

Validation of a Thermo-Ablative Model of Elastomeric Internal Insulation Materials

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In thermo-ablative material modeling, as in many fields of analysis, the quality of the existing models significantly exceeds that of the experimental data required for their validation. In an effort to narrow this gap, a laboratory-scale internal insulation test bed was developed that exposes insulation samples to realistic solid rocket motor (SRM) internal environments while being instrumented to record real-time rates of both model inputs (i.e., chamber pressure, total surface heat flux, and radiative heat flux) as well as model outputs (i.e., material decomposition depths (MDDs) and in-depth material temperatures). In this work, the measured SRM internal environment parameters were used in conjunction with equilibrium thermochemistry codes as inputs to one-dimensional thermo-ablative models of the PBINBR and CFEPDM insulation samples used in the lab-scale test firings. The computed MDD histories were then compared with those deduced from real-time X-ray radiography of the insulation samples, and the calculated in-depth temperatures were compared with those measured by embedded thermocouples. The results of this exercise emphasize the challenges of modeling and testing elastomeric materials in SRM environments while illuminating the path forward to improved fidelity.